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Reply to "Research incentives and research output"

A caution on quantity incentives and the use of economic models for higher education policy

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1 Introduction

Jorgensenn and Hanssen (2018) argue that the gross research output of individual academics, measured by the number of published pages, would serve as an acceptable basis for an incentive to increase academic research. An instinctive concern is that it would compromise research quality (not to mention teaching and academic citizenship activities). The authors' answer to this concern is that their formal model of academic behavior shows that, in fact, quality and quantity would increase proportionally in response to such an incentive. Since quantity is easier to observe and measure objectively, it follows that it is a preferable measure for performance and therefore incentivisation (Jorgensenn and Hanssen, 2018: 1045-1046).

There are various reasons why this striking result, and the associated policy proposals, warrants some interrogation. The first key premise of the analysis is that more academic output is inherently good. The second is that, given the desirability of increasing output, using extrinsic incentives is appropriate in the domain of higher education. Both these premises are subject to significant contention. The claim that gross research output is an inherent good (Jorgensenn and Hanssen, 2018: 1030) contrasts with concerns (Altbach and de Wit, 2018) that a significant proportion of rapidly-rising global academic research is of little or no value in itself, meaning in turn that the resources

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devoted to it are wasted and the volume itself has negative externalities.[1] Furthermore, in various countries and disciplines research incentives appear to have been associated with increases (in number or proportion) of lower quality and predatory publications. Such concerns in one middle-income developing country that utilises sizeable publication incentives (South Africa) have been noted and substantiated in a number of analyses (Vaughan, 2008; Thomas and De Bruin, 2015; Muller, 2017; de Jager, de Kock, and Van der Spuy, 2017; Mouton and Valentine, 2017; Tomaselli, 2018).[2] Beyond these consequence-oriented concerns, one may make the more profound objection that pecuniary incentives are inherently inconsistent with many conceptualisations of the university itself (Barnett, 2013).[3]

These issues provide some motivation for the detailed analysis of Jorgensenn and Hanssen (2018)'s counter-intuitive result that follows, but are set aside for the sake of engaging with the authors' formal analysis on its own terms. The first section, and focus of, the analysis addresses the claim that a formal model of academic behaviour implies that an salary incentive based on research output will not undermine output quality. I argue that this claim follows from two subtle modelling failures: an inadequate representation of an individual researcher's chosen (equilibrium) level of research quality, and an incorrect formulation of the policy problem. When these are corrected, the model produces an outcome that coheres with the intuition that an output-based incentive would undermine quality.

The second section raises four other modelling concerns: problematic assumptions; the conflation of assumptions and findings; (im)plausibility of some findings; and, the neglected importance of heterogeneity and temporal dynamics in the population of academics.

The final section briefly addresses a broader question, namely the limitations and dangers of utilising economic modelling to inform higher education policy in the manner Jorgensenn and Hanssen (2018) intend.

2 A refutation: a quantity incentive does reduce quality

As is customary in economic modelling, Jorgensenn and Hanssen (2018) (henceforth 'JH') begin with a discussion of a general model of academic behaviour

[1] These resources can be thought of in much broader terms than merely pecuniary ones. For instance, one could consider the opportunity cost of skilled individuals spending time on research that has neither intellectual nor practical value when they could be making other contributions to society.

[2] The authors acknowledge in passing that low quality publications are 'inevitable' (Jorgensenn and Hanssen, 2018: 1031) but do not elaborate on the reasons for that.

[3] The authors note, for instance, the tension between academic freedom and the manipulative intent behind pecuniary incentives (Jorgensenn and Hanssen, 2018: 1031) but proceed on the basis that "[New Public Management] has been the guiding governance model of university reforms in Europe for the last 20 years".

and then specify a functional form for the relevant dimensions in order to derive more detailed results. For the sake of brevity, the analysis that follows only repeats equations from their model where it is necessary to do so – the reader is referred to the original paper for more detail. For ease of reference these are denoted with their equation numbers in square parentheses, whereas the equations in our analysis are in ordinary parentheses.

2.1 Outline of concerns

There are three key equations specified by JH: a utility function for the hypothetical academic; a salary function; and, a research production function (Jorgensenn and Hanssen, 2018: 1039).[4]

$$U = U(\beta_1 S + \beta_2 lnL + \beta_3 P + \beta_4 Q) \quad [14]$$

$$S = \tau_0 + \tau_1 P + \tau_2 Q + \tau_3 E \quad [15]$$

$$Q = \alpha_0 t^{\alpha_1} T^{\alpha_2} I^{\alpha_3} \quad [16]$$

Academics are assumed to be driven by some combination of salary ('S'), research quality ('Q'), research quantity (in pages, 'P') and leisure time. Over some base level, salary is assumed to be determined by an additive combination of research volume, research quality and external activities ('E'). Finally, the quality of research is determined by an interactive combination of time spent reading relevant literature ('T'), time spent per page written ('t') and the academic's level of qualification or ability ('I').

JH follow standard modelling practice and derive optimal levels of relevant variables based on the assumption that our academic will maximise their utility function, through their choice of T, t, P and E. The key result for the conclusion and policy recommendation discussed above is:

$$Q^* = \frac{\beta_3 + \beta_1 \tau_1}{\alpha_1(\beta_4 + \beta_1 \tau_2)} \cdot P^* \quad [23]$$

JH rest their conclusion on the fact that equilibrium quality (Q^*) can be written as a positive function of equilibrium quantity (P^*). There are two immediate analytical concerns here.

First, as a matter of good practice: Q^* should be written in full as a function of only parameters and coefficients, then the effect of an output incentive on quality should be derived by taking the partial derivative of Q^* with respect to the parameter that captures the weight on quantity (τ_1).[5] This is no mere quibble, as will become apparent below.

[4] These are equations [14], [15] and [16] in the original paper.

[5] JH only provide, in the same equation, a reduced form version of Q^* as a function of parameters and coefficients and do not derive the relevant partial derivative.

Second, and relatedly, JH do not discuss other characteristics of [23] that are counter-intuitive. Notably, the form presented appears to suggest that Q^* is *lower* when there is greater weight on quality in the salary function (τ_2), but higher when there is greater weight on quantity. Even if one were to believe that a quantity incentive had a positive effect on quality, it seems surprising that a quality incentive is associated with lower equilibrium quality. On the face of it, then, [23] requires more explanation than is provided.

2.2 The actual effect of a quantity incentive

The representation of the relationship between quality and quantity in JH's model is subject to little justification or explanation, but even if we accept their formulation the framing of the *policy question* is flawed. Specifically, JH effectively envisage a quantity-based incentive as only increasing τ_1 but that does not reflect two critical real-world factors: policymakers have resource constraints and devoting resources to a quantity incentive necessarily means fewer resources for a quality incentive. Thus, for the model to represent *the policy problem* we require an additional equation that relates the weight of quantity (τ_1) and quality (τ_2).

To address our first concern, we write optimal quality solely in terms of model parameters and coefficients yields, with some simplification:[6]

$$Q^* = \left(\frac{\beta_3 + \beta_1\tau_1}{\beta_1\tau_3}\right)^{\frac{\alpha_1+\alpha_2}{1-\alpha_2}} \cdot (\beta_4 + \beta_1\tau_2)^{\frac{\alpha_2}{1-\alpha_2}} \cdot \alpha_2^{\frac{\alpha_2}{1-\alpha_2}} \cdot \alpha_0^{\frac{\alpha_2}{1-\alpha_2}} \cdot I^{\frac{\alpha_3}{1-\alpha_2}} \quad (1)$$

2.3 Recovering intuition

As noted above, for the policy problem to be realistic there ought to be a tradeoff between the weights placed on quality and quantity in the salary function shown in equation [15].[7] Although that issue is mentioned in the discussion (Jorgensenn and Hanssen, 2018: 1033-1034), it is not reflected in the specification chosen for the original salary function. For the sake of simple exposition, we utilise a simple linear representation:

$$\tau_2 = 1 - \tau_1 \quad (2)$$

In doing this we effectively supplement the authors' assumption that $\tau_1, \tau_2, \tau_3 > 0$ with an assumption that $\tau_1 + \tau_2 \leq w$ – where we choose $w = 1$ for simplicity.[8]

[6] This utilises equations [17] and [23] in the original paper; one could alternatively use [16], [18] and [19].

[7] In addition, even within the model without a tradeoff: for the policy analysis to be sufficiently thorough one should compare the effect of increasing the weight on quantity (τ_1) and increasing the weight on quality (τ_2).

[8] There should be no loss of generality provided the other model parameters are interpreted accordingly. An alternative, more complicated, approach would be to develop a

Substituting (2) into (1) yields:

$$Q^* = \left(\frac{\beta_3 + \beta_1\tau_1}{\beta_1\tau_3}\right)^{\frac{\alpha_1+\alpha_2}{1-\alpha_2}} \cdot (\beta_4 + \beta_1 - \beta_1\tau_1)^{\frac{\alpha_2}{1-\alpha_2}} \cdot \alpha_2^{\frac{\alpha_2}{1-\alpha_2}} \cdot \alpha_0^{\frac{\alpha_2}{1-\alpha_2}} \cdot I^{\frac{\alpha_3}{1-\alpha_2}} \quad (3)$$

The policy question raised by the authors is: what is the effect of an output-based salary incentive on an individual researcher's chosen ('optimal'/utility-maximising) quality? In the model this is equivalent to asking: what is the partial derivative of Q^* with respect to τ_1? The result based on (3) is shown in (4).

$$\frac{\partial Q^*}{\partial \tau_1} = \beta_1 \frac{\alpha_1 + \alpha_2}{1 - \alpha_2} \left(\frac{\beta_3 + \beta_1\tau_1}{\beta_1\tau_3}\right)^{\frac{\alpha_1+2\alpha_2-1}{1-\alpha_2}} \cdot (\beta_4 + \beta_1 - \beta_1\tau_1)^{\frac{\alpha_2}{1-\alpha_2}} \cdot (\alpha_0\alpha_2)^{\frac{\alpha_2}{1-\alpha_2}} \cdot I^{\frac{\alpha_3}{1-\alpha_2}}$$
$$- \left(\frac{\beta_3 + \beta_1\tau_1}{\beta_1\tau_3}\right)^{\frac{\alpha_1+\alpha_2}{1-\alpha_2}} \cdot \beta_1 \frac{\alpha_2}{1 - \alpha_2} (\beta_4 + \beta_1 - \beta_1\tau_1)^{\frac{2\alpha_2-1}{1-\alpha_2}} \cdot (\alpha_0\alpha_2)^{\frac{\alpha_2}{1-\alpha_2}} \cdot I^{\frac{\alpha_3}{1-\alpha_2}} \quad (4)$$

In order for an increase in the weight on publication quantity to have a positive effect on equilibrium quality we must have: $\frac{\partial Q^*}{\partial \tau_1} > 0$. Simplifying and solving (4) requires ascertaining the sign of the following expression:

$$(\beta_4 + \beta_1 - \beta_1\tau_1)$$

It is easy to see that this expression is positive if $\tau_1 < \frac{\beta_4+\beta_1}{\beta_1}$. The right-hand side is greater than one, which means that the condition is satisfied given the constraint we have placed on τ_1 and τ_2.

The resultant expression following from (4) is:

$$\tau_1 < \frac{\beta_4\tau_3\frac{\alpha_1+\alpha_2}{\alpha_2} + \beta_1\tau_3\frac{\alpha_1+\alpha_2}{2} - \beta_3}{1 - \beta_1\tau_3\frac{\alpha_1+\alpha_2}{\alpha_2}} \quad (5)$$

The expression is not sufficiently informative in this form but to focus on the question of interest, we make τ_3 equal to zero (i.e. the individual academic does not have remunerative external opportunities).[9] In that case, we have the following result:

$$\frac{\partial Q^*}{\partial \tau_1} > 0 \Rightarrow \tau_1 < -\beta_3 \quad (6)$$

Given that β_3 and τ_1 must both be positive, it follows that the expression cannot be satisfied. In other words, an increase in the relative weight placed on

constrained maximisation problem for the policy-maker with an appropriately formulated budget constraint.

[9] There is no reason – based on the structure of the model, or reality – to believe that eliminating external opportunities will affect the basic result of interest.

quantity does *not* increase equilibrium quality. Thus, accounting for the policymaker's trade-off yields the opposite result to that advanced in Jorgensenn and Hanssen (2018).

It seems likely that the failure to introduce an appropriate resource trade-off would also explain another of JH's counter-intuitive findings, namely that changes in fixed salary (τ_0) do not affect quantity or quality of research.[10]

3 Additional modelling concerns: assumptions, findings and plausibility

In addition to the specific claim addressed above, there are a number of other aspects of JH's analysis that merit comment. First, some of the assumptions in their model are problematic in what they imply about individual academic motives and the public good. Second, parts of the analysis conflate 'findings' and 'assumptions'. Third, the plausibility of certain findings/derivations is not established. Finally, while the paper discusses the possibility of heterogeneity among academic, it fails to adequately address the static and dynamic implications of this. I provide a brief sketch of each of these concerns below.

3.1 Problematic assumptions

Among the questionable modelling assumptions that are likely to have a material impact on the main findings are:[11]

- ☐ The utility function assumes that academics receive no utility from teaching or academic citizenship activities, only research, leisure time, salary and external activities that generate additional remuneration
- ☐ An individual academic's subjective perception of quality is assumed to coincide with the policymaker or manager's perception, which in turn is assumed to coincide with (unobserved) actual quality.

The overprioritisation of research outputs relative to teaching is a perennial concern raised within debates about policies within universities and higher education systems. A model that assumes no utility from teaching, and no link between time devoted to teaching and teaching quality, is problematic if it is then used to inform related policies. While it is entirely plausible that an academic may substitute time away from teaching in response to a research output incentive – thereby reducing teaching quality – there is no way to capture such negative effects in the model.

[10] This is particularly contrary to the intuition of the model itself. The finding that fixed salary does not affect optimal leisure time also contradicts the standard intuition of labour supply models.

[11] An example of a dubious assumption that is unlikely to affect the main results is the assumption that academic qualifications do not enter into the salary function (only the quality function).

The assumption of a correct, shared quality function is also problematic.[12] In developing higher education systems in particular, any of the relevant agents – university managers, policymakers and individual academics – may not have informed/accurate notions of what constitutes quality research. All else equal, if those providing the incentive cannot distinguish low quality work from high quality work (Q in the salary function is observed imperfectly) then academics will maximise utility by producing lower quality work, limited only by their instrinsic attachment to their own perceptions of quality (β_4).

3.2 Assumptions are not findings

It is profoundly important to distinguish modelling assumptions from findings, but in a number of places JH conflate these. For example, they state that: "our model results imply that every researcher's utility increases with salary and the potential for external income and decreases with teaching duties" (Jorgensenn and Hanssen, 2018: 1044). However, as noted above: the model *assumes* academics get no utility from teaching by omitting this from the utility function. The same is true for external income, which provides utility via the salary function.

Another example, linking to our analysis in 2, is the claim that JH 'find' that "changing the basic salary will not influence the researcher's behaviour and, thereby, the quantity (P^*) and quality of his research (Q^*)" (Jorgensenn and Hanssen, 2018: 1045). Aside from the oddity of such a result in comparison to typical economic models of this kind, where higher fixed income would increase optimal leisure time, the finding is likely to be the direct consequence of assuming that there is no trade-off between the basic component of the salary (τ_0) and the output-related components (τ_1 and τ_2).

3.3 Plausibility of findings

A number of JH's findings are counter-intuitive, either in relation to standard economic models of labour supply or in relation to the academic context to which their model applies. In and of themselves, counter-intuitive findings are not problematic – indeed, some economists hold the view that *only* counter-intuitive modelling results are of interest – but they require additional explanation. Specifically, it is necessary to explain what mechanisms in the model produce those results. Without such explanation, such findings may point to flaws in the model or modelling assumptions.

[12] JH state that: "we have made the tacit assumption that the researcher's perception of the quality of his research...coincides with the employer's perception in the salary function...This is an important and reasonable assumption" (Jorgensenn and Hanssen, 2018: 1035).

In section 2 we have of course already dealt with the most striking of the implausible findings. Among the other findings that appear puzzling sans further explanation are:

- ☐ Optimal leisure time is unaffected by the fixed component of the salary, the quality and output incentives, the utility gained from research, or the parameters of the quality production function
- ☐ Time spent per page of research (t^*) *increases* with the weight on pages of output in the utility and salary function[13] (Jorgensenn and Hanssen, 2018: 1041-1042)
- ☐ Teaching and related time (D) can be increased without affecting quantity or quality of research.

In textbook models of labour supply, an increase in fixed salary beyond a certain point increases optimal leisure time. At the margin, one would similarly expect greater absolute incentives for quality and quantity of research to decrease leisure time. And that time spent per page would be lower/*decrease* with the utility and salary weights on output, since the researcher would care less about quality and more about pages produced.[14] Finally, the finding that increasing teaching load only affects (remunerated) external activities cannot hold where such activities are non-existent; the nature of time constraints means that in such situations it must affect research or leisure time.

In the absence of a detailed elaboration of the underlying mechanisms that produce such counter-intuitive results, it is difficult to attribute much significance to them.

3.4 Heterogeneity and temporal dynamics of the population of academics

In a number of places, JH allude to the possible implications of variation among academics and even across institutions. However, this is generally in relation to factors outside the model, whereas there are various characteristics of the model itself that necessitate such analysis – especially if it is intended to inform policy.

The omission of teaching from the utility function is one example of how the model imposes a homogeneity assumption on the population of academics. Furthermore, the model implicitly assumes identical values to all the parameters and coefficients within the population of academics. For policy purposes this is inadequate.

[13] The result in [18] of the original paper also implies that if an academic receives no utility from research quantity and there is no quantity incentive, then they will spend zero time per page in equilibrium, which makes no sense.

[14] The explanation JH provide argues that this is a function of a maximising trade-off within the salary function, but that explains why an academic would increase the number of pages written – not time per page.

Consider again JH's main proposal pertaining to a research output incentive. Where there is variation in academics' intrinsic motivation to produce quality research (β_4) relative to the utility they get from income (β_1), under a standard optimisation framework academics with the least intrinsic motivation will react the most to an incentive. Furthermore, academics with lower ability and lower intrinsic motivation will produce more pages in equilibrium than academics with higher ability and greater intrinsic motivation. Where there is a trade-off in the allocation of public resources, as I have suggested must be the case, this means that an increasing proportion of resources will be allocated to those who produce for the sake of page numbers rather than substantive intellectual contribution. And that the total output of academic research will increase primarily through the higher contributions of extrinsically motivated academics.

As JH note, their model does not capture dynamics across institutions and over time (Jorgensenn and Hanssen, 2018: 1043-1047). The consequences of intra-population heterogeneity described above could also lead to selection into and out of the academic population over time. At the margin, 'outside options' for academics who are more intrinsically motivated will become .[15]

4 Economic modelling and higher education policy

One common response to concerns about realism of assumptions and limitations of formal models is to say that 'models are necessarily simplifications of the real world otherwise they would not be useful'. The analogy of maps is often used: a map would not be useful if it was made on a 1:1 scale.[16] However, the problem this raises is: what level of 'realism' is sufficient to produce findings that are plausibly accurate? Given the profound epistemological, ontological and even metaphysical, questions this raises, it is hardly surprising that this remains the subject of active philosophical and methodological debate in a number of disciplines. In the current context, its narrower instantiation is: how informative is economic modelling of academic behaviour in higher education research and policy? A detailed exposition is not possible here, but I provide a sketch of the epistemological and methodological concerns. The position I endorse is decidedly negative.

The role of mathematical models in economics has generally been taken for granted by economists since 'formal' approaches came to dominate the discipline in the early to mid-twentieth century. However, for methodologists

[15] In economic modelling, the affect on research quality would be at the 'intensive margin' while the effect on the population of academics would be at the 'extensive margin'.

[16] The map analogy is often attributed to a story by Lewis Carroll.

and philosophers the role and realism of models remains the subject of unresolved contention (Mäki, 2002; Hands, 2013; Aydinonat, 2018).[17] To simplify matters, we may think of such models playing two roles: contributing to our understanding, and serving as a basis for prescription. There is general agreement that the latter, which is what JH seek to do with their policy proposals, places much greater demands on any model. For instance, Pearl (2009) has developed an entire theoretical framework (the 'do calculus') that formally distinguishes variation created by an exogenous intervention from variation that occurs within a system. And dissatisfaction with formal models has been one of the main factors behind the rapid increase in experimental methods in empirical work in economics (Angrist and Pischke, 2010).

An important criticism within the extant literature is that economic models of behaviour necessitate the downplaying of unmeasurable and complex relationships in order to render the analysis tractable.[18] In the present case, for instance, the relationship between 'institutional culture' and intrinsic incentives (parameters in the utility function) may be mentioned as a qualitative aside (Jorgensenn and Hanssen, 2018: 1045) but is not modelled. So while JH acknowledge the importance of intrinsic motivation and include it within the representative academic's utility function, it is not represented as manipulable by policy and therefore cannot be reflected in the policy recommendations and alternatives *based on the model*.

A popular example of the success of economic modelling may assist in making the point. A number of authors have discussed the success of economic models of auctions. Leaving aside the fact that applying such model is an art in itself (Klemperer, 2004), auctions are quite unique environments. Among the key characteristics of the auction case are: the question of interest is typically the maximisation of financial returns; the notion that a market value is equivalent to a notional objective value of the good is relatively uncontentious; the motives of all economic agents can be assumed to largely reflect extrinsic (pecuniary) factors; all key dimensions of the auction environment, within which the model seeks to predict behaviour, are subject to the design of the policymaker themselves. In the case of higher education research, I would suggest that these characteristics do not hold and, further to the question of the nature of the university itself, it would be *inherently undesirable* for that to be the case.

As a purely intellectual activity, there is nothing *inherently* wrong with using formal models of individual behaviour to analyse academic incentives and outcomes. However, there are numerous reasons to be deeply sceptical of claims

[17] Economists themselves tend to limit contributions to this area to justifications for, or rationalisations of, the status quo (Gilboa, Postlewaite, Samuelson, and Schmeidler, 2014; Rodrik, 2015).

[18] JH in fact discuss an aspect of this in relation to their transition from a general model to one with very specific functional forms.

that such models provide insight that cannot be provided by other methods, that the insights so provided are more credible than other methods or insights (including simple intuition), and that findings of such models can be used as a foundation for policy interventions. As the preceding formal analysis shows, the use of mathematical models can also (even if unwittingly) conceal problematic assumptions from many readers and that in itself is a weakness. These concerns apply to many other disciplines where such modelling is used. Nevertheless, the paper by Jorgensenn and Hanssen (2018) is perhaps to be welcomed in as much as it serves to draw attention in higher education research to these important issues and serves as a basis for future debate.

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